ARMY RDT&E BUDGET ITEM JUSTIFICATION (R-2 Exhibit)

DATE: February 2000

BUDGET ACTIVITY: 2 - Applied Research

PE NUMBER AND TITLE: 0602786A Warfighter Technology

COST (*In Thousands*)	FY 1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
Total Program Element (PE) Cost	18075	25831	24659	26429	24934	23848	23444	Continuing	Continuing
AC60 AC60	1856	2048	905	2083	1706	1031	1080	Continuing	Continuing
AH98 Clothing and Equipment Technology	10032	16120	16477	17107	15947	15877	14609	Continuing	Continuing
AH99 Joint Services Combat Feeding Technology	4526	4853	5077	5043	5383	5283	5493	Continuing	Continuing
D283 Airdrop Advanced Technology	1661	2810	2200	2196	1898	1657	2262	Continuing	Continuing

A. Mission Description and Justification: The goal of this program element is to improve soldier survivability and performance by providing research and technologies for: combat clothing and personal equipment; combat rations and combat feeding equipment; and the air delivery of personnel and cargo. The Clothing and Equipment Technology project provides cutting edge research and technologies for clothing, equipment, and high-pressure airbeam supported shelters. Technologies will enhance warfighter protection from both combat threats (e.g., ballistics, lasers, flame) and the field environment; enhance signature management and integration; and significantly lighten the soldiers load. Human science is incorporated into modeling and analysis tools that will enable technologists and military users to trade-off potential warrior system capabilities and develop a human-centered warrior system design. The Joint Services Combat Feeding Technology program supports all Military Services, the Special Operations Command, and the Defense Logistics Agency with research and development of high impact/high payoff technologies for performance enhancing combat rations, packaging, and combat feeding equipment/systems. Research will enhance nutrient composition and consumption to maximize cognitive and physical performance on the battlefield; minimize physical, chemical and nutritional degradation of combat rations during storage; meet the needs of individual soldiers in highly mobile battlefield situations; and provide equipment and energy technologies to reduce the logistics of field feeding while improving the quality of food service. Similarly, the Airdrop Advanced Technology project supports all Services' requirements for air dropping larger combat and logistics loads while improving delivery accuracy, minimizing vulnerability of aircraft, and reducing life cycle costs. Providing technologies for safer, more combat efficient personnel parachutes addresses a critical capability for rapid force projection, particularly into hostile environments. The work in this program element is consistent with the Army Science and Technology Master Plan (ASTMP) and the Army Modernization Plan. It adheres to Tri-Service Reliance agreements on clothing, textiles, and operational rations and field food service equipment, with oversight and coordination provided by the Human Systems Reliance Panel, the Warrior Systems Technology Base Executive Steering Committee, and the DoD Food & Nutrition Research & Engineering Board. There is no unwarranted duplication of effort among the military departments. Efforts are coordinated with those in PE 0603001A (Warfighter Advanced Technology). The program is managed by the U.S. Army Natick Soldier Center, Natick, MA.

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B. Program Change Summary	FY 1999	FY 2000	FY 2001
Previous President's Budget (FY 2000/2001 PB)	18420	23971	23405
Appropriated Value	18661	25971	
Adjustments to Appropriated Value			
a. Congressional General Reductions	-241		
b. SBIR / STTR	-211		
c. Omnibus or Other Above Threshold Reductions		-63	
d. Below Threshold Reprogramming	-60		
e. Rescissions	-74	-77	
Adjustments to Budget Years Since FY 2000/2001 PB			+1954
New Army Transformation Adjustment		TBD	-700
Current Budget Submit (FY 2001 PB)	18075	25831	24659

Change Summary Explanation: Funding FY01 Project D283 was adjusted to reflect the new Army Transformation.

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BUDGET ACTIVITY 2 - Applied Research	PE NUMBER AND TITLE 0602786A Warfighter Technology
	PROJECT AH98

COST (*In Thousands*)	FY 1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
AH98 Clothing and Equipment Technology	10032	16120	16477	17107	15947	15877	14609	Continuing	Continuing

Mission Description and Justification: This project researches and matures technology to improve soldier survivability and performance. Areas of emphasis include: research to significantly lighten the soldier's load; lightweight materials for personal survivability (e.g., improved ballistic, flame, and directed energy protection, enhanced signature management); human science, modeling and analysis tools for optimizing soldier system clothing and equipment; three-dimensional textiles for achieving rapidly deployable wide-span airbeam supported shelters. The program was restructured due to increased priority for ballistic protection in FY00, and for human science, modeling and analysis aspects of the soldier system in FY01.

FY 1999 Accomplishments:

- 3662 - Completed integration of improved small arms protective material systems and began transition to enhance individual armor items; transitioned high strength fiber composite technology for lightweight fragmentation protective helmet; and expanded fundamental understanding of key property requirements for optimization of new materials for next generation multiple ballistic threat protection (increases small arms, advanced fragmentation, and improved blast protection).
  - Demonstrated improved corrosion resistance using a novel conductive polymer in coatings on steel; developed silk fabrics and blends of silk/kevlar and silk/spectra for evaluation for ballistic impact resistance; developed methods to create composite of nanoscale ceramic and metal particles and polymers including electrospun membranes of nanofibers for soldier protective items; demonstrated that metal nanoparticulate coatings increased the toughness of surface treated fibers; nylons compounded with nanoclay have been obtained and melt spun into nanocomposite fiber for the first time for flame resistance testing.
- 3355 - Defined the effects of a range of load weights on biomechanical performance of the soldier including walking gait and the forces to which the soldiers' body is exposed to while carrying loads; demonstrated that biomechanically enhanced combat boots improve performance and are highly acceptable and durable for use under military field conditions; expanded anthropometric data extraction software capabilities to include a larger number of critical body measurements required for clothing/equipment system design and evaluation.
  - Expanded current physiological model capabilities from restricted laboratory settings into more representative virtual combat environments by incorporating the Surgeon General's SCENARIO model into the Integrated Unit Simulation System (version 3.1) individual/small unit combat model. This provides more accurate representation of the effects of heat stress and hydration on warrior performance in mission simulations.
- 3015 - Established performance based protection criteria for flame resistant combat clothing.
  - Demonstrated in a dismounted operational setting, six passive thermal signature management technologies integrated into breadboard prototype combat uniforms.
  - Designed optical limiting cells that can be used in breadboard tunable laser eye protective device.
  - Researched methods to scale up three-dimensional textile technology using subscale prototypes that will ultimately provide highly mobile maintenance shelter capability for large weapons platforms, such as attack helicopters and tanks.

Total 10032

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FY 2000 Planned Program:

•	4220	- Validate ability of virtual prototyping tools to analyze form, fit, function, and assist in infantry warrior system design; demonstrate the ability to disperse nano-particles in a variety of polymer structures likely to be applied in the warrior system as the first step towards significant weight reduction of the heaviest components. - Develop battlefield scenarios to appropriately model the combat effectiveness of warrior systems and components in the Integrated Unit Simulation System (IUSS).
•	4490	- Mature and transition technology to the PM-Soldier that reduces the system weight of the individual countermine protective system (fielded in FY96) by 35%, while providing equal protection; define requirements for assessment criteria and test methodology to determine ballistic casualty reduction potential of emerging technology; evaluate novel materials/systems demonstrating concepts to increase protection and reduce weight of personnel armor, for both head and torso, against emerging ballistic threats.
•	2251	- Quantify the effects of load-carrying gear, clothing, and individual equipment configured for specific squad positions on human performance; complete and successfully demonstrate a passive dynamic gait model; support integration of automated measurement and data extraction system for human-system interface analysis and military clothing sizing and issue. - Synthesize new polymers that have shown great potential for application in the development of lightweight, flexible and wearable power generating devices for soldier systems. - Research novel techniques for integrating electronic components, such as cables, connectors, sensors and antennae, into textile material systems to enable more effective integration of electronics in the soldier system, reducing weight and enhancing reliability and fightability.
•	1960	- Design a dismounted soldier system signature evaluation and analysis plan to determine the baseline total system signature (i.e., visual, near-, mid-, and far-infrared, acoustic, electromagnetic); analyze experimental thermal signature reducing facepaint formulations to provide safe and effective means to manage the thermal signature of exposed skin. - Increase the level of achievable laser eye protection using polymer-based limiters to support all warrior, both mounted and infantry, in the Future Combat Systems (FCS). - Develop and demonstrate a test methodology for flame resistant material systems. - Conduct advanced helmet design and capability trade study with the infantry user that will lead to future helmet design concepts with integrated situational awareness, system control, and survivability capabilities.
•	2924	- Optimize the wide span airbeam textile construction and complete the full-scale shelter design; begin fabrication of a breadboard full-scale 60 ft wide airbeam supported shelter for field demonstrations. - Investigate technical issues related to improving the reliability, affordability and safety of airbeam technology; determine failure mechanisms of high pressure airbeams and improve manufacturing techniques for continuous braiding and weaving processes.
•	275	- Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR).
Total	16120	

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FY 2001 Planned Program:

•	5785	- Evaluate and mature technology for virtual prototyping tools to develop warrior system designs, with a focus on integrated load carriage and helmet design, component/capability placement on the torso and head; demonstrate the feasibility of incorporating nano-scale materials in soldier system components to reduce weight. - Determine adequate level of human system data points required to enable quantitative measures of soldier system performance, validation of small unit combat analysis models, and development of soldier system virtual prototyping and design tools; begin focused effort to collect required human system data.
•	5845	- Extend the IUSS individual/small unit combat model to develop the initial ability to assess the effects of restricted terrain (e.g., rooms, hallways, trenches) on warrior system performance. - Transition improved test methodology/assessment criteria for personnel armor systems to the acquisition community to enable the trade-off of protection, weight, mobility and affordability; mature novel concepts to increase protection and decrease the weight of personnel armor components.
•	2392	- Determine effects of varied topographic and terrain conditions on human performance through biomechanical evaluations; extend the passive dynamic gait model to encompass terrain data; augment 3-D anthropometric scanning capabilities to include tools for applications supporting human-based modeling/simulation and novel uniform and equipment virtual prototyping and design concepts. - Research and process conductive polymers, using novel electrospinning techniques, into a material structure with very high surface area; assess photovoltaic and energy density potential for future power generating devices. - Demonstrate breadboard prototype concepts for integrating electronic components into textile material systems as an initial integrated personal body local area network for soldier systems.
•	2455	- Demonstrate 30-50% cost decrease compared to the cost of existing flame-resistant clothing systems while maintaining multiple threat protection levels. - Demonstrate baseline dismounted soldier full spectrum system signature evaluation and analysis. Recommend corrective actions, if necessary. Down-select face paint formulations and prepare an evaluation plan to determine effectiveness of these materials as a safe means to manage the thermal signature of exposed skin area. - Modify the brassband prototype design of millimeter-lens arrays for laser eye protection devices to decrease the length of the optical assembly to make them more compatible with human factors criteria. This supports all warriors, including mounted and infantry, in the Future Combat Systems (FCS). - Demonstrate the ability of an airbeam supported structure to span a cross section exceeding 60 feet in width to enable the development of a rapidly deployable large weapons platform maintenance shelter.
Total	16477	

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	PROJECT AH99

COST (*In Thousands*)	FY 1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
AH99 Joint Services Combat Feeding Technology	4526	4853	5077	5043	5383	5283	5493	Continuing	Continuing

Mission Description and Justification: The goals of the Joint Services Combat Feeding Technology project are to provide combat feeding and food system technologies to enhance the survivability, sustainability, and supportability of the Armed Forces by ensuring optimal nutritional intake. Thrust areas include applied research of combat rations, packaging, and combat feeding equipment/systems. Near-term goals include: enhancing nutrient composition and consumption to maximize cognitive and physical performance on the battlefield; reducing ration weight/volume and food packaging waste to minimize the logistics footprint; tailoring rations to the combat situation and radically improving mobility; reducing replenishment demand by extending shelf-life; permitting more extensive prepositioning of stocks, while maintaining initial quality; and providing equipment and energy technologies to reduce the logistics of field feeding while improving the quality of food service. The work in this project supports all military Services, Special Operations Command, and the Defense Logistics Agency. This is a DoD program for which the Army has Executive Agency responsibility.

FY 1999 Accomplishments:

- 770 - Completed field trials of prototype individual beverage heaters to ensure warrior hydration, and transitioned to ration improvement program for large-scale field test.
  - Completed testing of mini-tube and autothermal reformer critical subsystems for logistically improved fuel cell based cogenerator.
  - Down-selected micro fuel atomizer approaches, and designed and fabricated a 1-2 k British Thermal Unit/hr burner weighing less than 4 oz which provides individual soldier water and food heating capacity.
- 902 - Completed test and evaluation of waterless kitchen sanitation nonstick coatings and environmentally acceptable grease separation of wastewater, and transitioned these logistics improvements to advanced field food sanitation center.
  - Developed concept and subsystems for reliable passive cold storage and frozen food handling systems for field kitchens to enable more fresh and frozen foods while ensuring food safety.
  - Investigated Liquid-Injection Cogeneration (heat and electric from one process) for applications with potential dual use in military field services (kitchen, showers, laundries, space heating, etc.), significantly reducing logistical footprint and replenishment demands.
- 1233 - Evaluated evolving advanced dehydration technologies for ration components to exploit novel ingredients/processes for stabilizing structure and for controlling microbial growth to increase variety of shelf stable ration components; optimized processing and defined packaging specifications for shelf-stable vegetables and fruit combat ration components; transitioned osmotic dehydrated fruit to Meals Ready to Eat (MRE).
  - Conceptualized the composition and configuration of a tailorable and modular combat ration, and designed packaging concepts compatible with the tailoring of modules for either minimally or fully sustaining rations which reduce soldier load.
- 1621 - Evaluated and developed nutraceutical prototypes containing glutamine, caffeine and tyrosine for ration supplementation to optimize combat effectiveness.
  - Evaluated concepts for bioengineering of high energy ration components including incorporation of complex “nutri-fuels” into rations for improved performance/stress reduction and protein enhancement of ration components for improved nutritional quality.

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FY 1999 Accomplishments: (continued)

- Evaluated concepts for bioengineering of high energy ration components including incorporation of complex "nutri-fuels" into rations for improved performance/stress reduction and protein enhancement of ration components for improved nutritional quality.
- Developed four new irradiated meat entrees for the National Aeronautics and Space Administration, evaluated laminate packaging films, and transitioned program to Advanced Technology Development.

Total 4526

FY 2000 Planned Program:

- 2139 - Downselect or combine competing reformer approaches and integrate with fuel cell and field kitchen thermal fluid heater to substantially increase heat transfer efficiencies by converting waste heat to useful energy; test and evaluate reformer with fuel cell and field kitchen thermal fluid heater and transition to Advanced Technology Development for field kitchen technology demonstrations.
- Mature technology on critical subsystems for Liquid-Injection Cogeneration (fluid, heat exchanger and expander) to reduce the logistics footprint; weight, and field kitchen fuel requirements.
- Prototype and test reliable passive cold storage and frozen food handling systems for field kitchens to reduce requirement for fuel and enhance Class I logistics/distribution; transition to Advanced Technology Development.
- Design and fabricate prototype Pocket Stoves to provide warrior light weight capability to heat beverages, conduct bench level performance tests and collect early user feedback.
- Conduct material research on thermal fluid heat transfer systems which reduce the burner requirement from, as many as 6, to as few as 1, reducing weight of deploying forces and substantially reducing Operations & Support costs; transition data to Kitchen Performance Specification.
- Conduct concept analysis and design of Self Heated Meals for Remote Site Feeding including module size, chemical heater and activator, and methods for efficient heat transfer to provide enhanced forward positioning capabilities and quality group meals without food service equipment.
- Conduct front end analysis of food and packaging field waste management methods and provide field management alternatives for implementation by appropriate agency.

- 1408 - Complete product development and mature technology for microwave sterilized meals through a commercial contract to improve nutritional/sensory quality.
- Complete demonstration studies on enhancers/antioxidants and packaging models for combat optimized ration components which enhance cognitive/physical performance.
- Conduct field evaluations on items produced by novel dehydration technologies in combat ration products, demonstrating significant reduction in weight and cube of combat ration components.
- Research and test of engineering processes for production of carrier matrices for bioengineered protein systems to enhance nutrition value for optimized future combat rations.
- Conduct initial testing and mature technology for methodologies/carriers for smart food components optimizing metabolic transfer conversion to energy sources to enhance the combat performance of troops.

FY 2000 Planned Program: (continued)

•	1266	- Research the feasibility of accelerating the osmotic dehydration of fruits by sugar solutions and by employing both single and repeat cycles of high pressure to reduce processing cost of these ration components. - Research the feasibility of incorporating nano-sized fillers into commercially available packaging materials optimizing barrier properties to extend ration shelf-life. - Identify technologies for the conversion of native cellulose to foodstuffs for revolutionary survival ration; conduct a market/literature survey to assess current conversion/digestion systems. - Investigate the production of volatile compound(s) that are unique to specific foodborne pathogens; grow bacteria on selected food models (protein, fat, carbohydrate) to determine the effects of food composition on chemical volatile distribution to provide handheld biosensor for field/combat use.
•	40	- Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR).
Total	4853	

FY 2001 Planned Program:

•	1624	- Integrate and test subsystems for Liquid-Injection Cogeneration, optimizing waste heat conversion and user safety, and transition to Advanced Technology Development for field kitchens. - Develop packaging for Self Heated Meals for Remote Site Feeding including integration of food and heaters, and heat transfer modeling and testing to ensure environmental compliance and optimum performance at lowest cost. - Complete development of Soldier Pocket Stove technology and transition to Advanced Technology Development to validate revolutionary non-powered combustion technology.
•	2182	- Mature technology and test combat optimized ration components to increase cognitive/physical performance. - Complete study on engineered carrier matrices for bioengineered proteins which provide performance enhancing nutrients for military rations in a portable, easily consumed, acceptable form and transition to Advanced Technology Development. - Complete field test of products produced with advanced dehydration technologies which reduce ration weight, volume and total logistics costs; transition to fielded individual/group ration improvement program. - Fabricate prototype ration quality status indicators that can be monitored externally by logistics personnel to ensure least fresh, first out. - Research and design ration packaging systems that will respond to the environment to provide a single packaging system for all rations with reduced signature. - Develop totally integrated Class I supply/requisition/distribution concepts that support DoD/DA logistic initiatives and minimize Class I logistical support impacts and theater stockpiles. - Mature encapsulation technology and finalize selection of methodologies/carriers for smart food ration components and prepare for FY02 validation testing. - Engineer new delivery systems (i.e., gels) for the incorporation of performance enhancing agents. - Research and mature packaging technology that prevent lipid oxidation, minimize undesirable odors, and help prolong quality retention of shelf stable ration items.

FY 2001 Planned Program: (continued)

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		- Determine requirements and test the efficacy of intercomponent films of multi component ration items to increase product quality and menu variety
•	1271	- Evaluate pressure effects on texture mediated by activation/release of native enzymes in fresh vegetables (pectin esterases) or meats (proteases) as a pretreatment to reduce dehydration or thermal processing requirements for ration components, while maintaining initial quality - Conduct processing trials to determine feasibility of utilizing and/or modifying existing methods and techniques; optimize processing parameters to enhance orientation of nano-composite fillers, such that gas diffusion will be minimized, extending barrier protection for combat rations - Explore the feasibility of non-enzymatic hydrolysis techniques, such as acid or alkaline hydrolysis, alone or as a pretreatment to enzyme hydrolysis for potential conversion of biomass to food stuff which would support soldiers in survival situations. - Conduct tests with mixed culture samples to evaluate the potential and time for detecting and differentiating specific volatile compounds from food pathogens for use in easy-to-use, lightweight, field biosensor.
Total	5077	

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PROJECT: D283

COST (*In Thousands*)	FY 1999 Actual	FY 2000 Estimate	FY 2001 Estimate	FY 2002 Estimate	FY 2003 Estimate	FY 2004 Estimate	FY 2005 Estimate	Cost to Complete	Total Cost
D283 Airdrop Advanced Technology	1661	2810	2200	2196	1898	1657	2262	Continuing	Continuing

Mission Description and Justification: This project provides applied research to enhance personnel and cargo airdrop capabilities. These are key capabilities for force projection, particularly into hostile areas. Areas of emphasis include parachute technology for improved performance, precision offset aerial delivery, soft landing system development, airdrop simulation, and low altitude/high speed airdrop systems technologies. Efforts will result in increased personnel safety, more survivable and more accurate cargo delivery and reduced personnel, aircraft, and cargo vulnerability. All the aforesaid will enhance the military's capability for global precision delivery and rapid force projection.

FY 1999 Accomplishments:

- 1160 - Constructed new prototype cargo parachutes based on the new design for a lightweight, low bulk, low altitude, affordable cargo parachute.
  - Downselected an air release valve and designed and constructed an airbag system prototype for roll-on/roll-off cargo airdrop.
  - Tested the pneumatic muscle for soft landing of payloads.
  - Investigated the new parafoil inflation method for cargo airdrop to increase reliability of full parafoil deployment.
- 501 - Applied state-of-the-art parachute system models to analyze performance, minimize full-scale airdrop testing, and assist in design trade-off decisions. Models included: soft landing; trajectory; and guidance navigation and control models.
  - Completed first generation simulations of fully coupled 3D parachute inflation model on round systems and disreefing models of cross and gliding wing systems; validated results with experimental data.
  - Demonstrated parachute/wind interaction model and validated from on-going science and technology programs in the Army and Air Force.

Total 1661

FY 2000 Planned Program:

- 1184 - Mature smart airbag technologies for roll-on/roll-off cargo airdrop and transition to technology integration in 0603001A (Project D242).
  - Research advancement of soft landing of personnel by a combined parachute and pneumatic muscle system.
  - Research a concept for a pneumatic muscle soft landing system for heavy cargo using subscale testing and modeling and simulation.
  - Investigate advanced, low-cost parafoil designs for improved flight and landing flare performance.
- 608 - Apply state-of-the-art airdrop system models to reduce (by as much as 10%) the life cycle costs by: minimizing feasibility testing; providing predictions of system limitations; shortening development cycle times; and predicting the effects of system modifications.
- 975 - Research concepts for an advanced precision air delivery system for future combat vehicles; conduct trade-off analysis and lab testing.
- 43 - Small Business Innovation Research/Small Business Technology Transfer (SBIR/STTR).

Total 2810

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PROJECT D283	

FY 2001 Planned Program:

•	1252	- Identify and analyze candidate concepts for a low cost, precision airdrop resupply capability for humanitarian and other one-time-use operations. - Conduct feasibility experiments with candidate low cost precision concepts. - Construct and experiment with an advanced, low-cost parafoil with improved flight and landing flare performance.
•	648	- Incorporate additional advanced features into a second generation 3D high performance airdrop system model and validate with concurrent experimentation. - Simulate airdrop systems of interest to DoD, transition results and package software into a user-friendly graphical user interface environment for use as an “airdrop virtual proving ground”.
•	300	- Evaluate multiple design concepts for advanced precision aerial delivery of future combat vehicles and identify best candidate for testing.
Total	2200	